International Polar Year:

Unique Research and Educational Opportunities

Statement of

Donal T. Manahan, Ph.D.

Professor of Biological Sciences

University of Southern California

Los Angeles, CA 90089-0371

Before the

Subcommittee on Research

Committee on Science

U.S. House of Representatives

September 20, 2006.

Good morning, Mr. Chairman and Members of the Committee. Thank you for the opportunity to speak to you today as you consider the scientific agenda and the Federal role for the International Polar Year.

My name is Donal Manahan. I am a professor of biological sciences at the University of Southern California (USC). I have conduced research as a chief scientist and field-team project leader in Antarctica for over 20 years. I have previously served as the chair of the National Research Council's Polar Research Board for 3 years (1999 to 2002). The National Research Council is the operating arm of the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine of the National Academies, chartered by Congress in 1863 to advise the government on matters of science and technology. In addition to my teaching and research experiences at my university, I have served as director of environmental science programs for both undergraduate education and graduate research; have been the chair of the USC Department of Biological Sciences; and Dean of Research for the USC College of Letters, Arts, and sciences.

My comments today will address the upcoming International Polar Year (IPY, March 2007 through March 2009) in the context of (i) what has been learned from polar research and IPYs in the past; (ii) what are the most critical unanswered questions that we hope to resolve during this IPY; (iii) why educational and research activities during IPY are important to us here in the US; and (iv) the societal benefits of IPY. I will focus most of my comments on Antarctica. I believe my colleagues on this panel will address other aspects and regions of polar research.

Regarding current impact from past IPYs, accurate scientific knowledge and current public awareness of the importance of polar regions to our planet as a whole is still a fairly recent occurrence. For instance, in 1963 National Geographic released a map of Antarctica that [quote] “revolutionizes our conception of its geography.” Taken in the context of the many centuries of geographic exploration of our Earth, it is quite remarkable that it was only about 40 years ago that more accurate maps of Antarctica emerged. Such maps still continue to be refined to this day. Antarctica has long been considered to be the “last and loneliest of the seven continents” (National Geographic, 1963). Following the “Heroic Age” of early exploration of polar regions in the late 19th and early 20th Centuries, the modern understanding of Antarctica began in earnest with the great international effort of IPY3 – The International Geophysical Year of 1957-58. Yet the growth of awareness of the importance of polar regions by many educators, scientists, and the public in general (i.e., by those not already living in polar regions) is a fairly recent occurrence. I will expand further on this point, as I believe it is important in the context and timing of the next IPY.

Both polar regions of our planet are now known to be capable of undergoing very rapid change. In the mid-1980s, the rapid opening of the “Ozone Hole” over Antarctica was certainly one of the great surprises in environmental science during the latter part of the 20th Century. Rapid rates of change for important processes in polar regions, such as ice sheet stability, ozone chemistry and biological rates, have surprised many scientists. Announcements of these rapid changes have also surprised the public at large. Today phrases and concepts such as “Abrupt Climate Change” and “Surprises” regarding our environment are now in common use in scientific publications, in media presentations, and in educational settings. The recent National Academy Press publication on "*Abrupt Climate Change: Inevitable Surprises*" provides an excellent report on this subject of rapid change. There is no doubt in my mind that further research in polar regions is absolutely essential for understanding our planet and for being better able to predict environmental change and its impact on life on Earth.

The specific research questions that will be addressed during this next IPY are still under review through our own national agencies and through collaborations with international partners. As I believe will be highlighted by others during this hearing, the current list of potential educational and research projects is extensive. Here I would like to compliment NSF, the National Academies' Polar Research Board and other polar scientific groups and agencies for doing an excellent job of coordinating these complex national and international activities and for helping raise awareness of the importance of polar research.

Regarding the approach to undertaking future research, one important point that I do want to emphasize is that the next IPY will differ from previous ones in enhancing our understanding of polar regions through novel, cross-disciplinary research. For instance, during the International Geophysical Year in the 1950s, the focus then was more on the physical sciences. For the next IPY, the scientific focus will be more cross-disciplinary – involving biological, chemical, physical, and social sciences to better understand polar regions. In my own area of expertise, the biological sciences, I foresee an exciting interplay between the physical and the life sciences. An example of such collaboration is that as physical scientists provide a better understanding and predictability of temperature change, biologists will be better able to undertake more realistic experiments to define biological responses of organisms to such changes (e.g., temperature adaptation, timing of life cycles, and other ecological changes). Research during IPY will certainly span from the scale of individual molecules and genes to the larger scale of whole oceans and continents.

A point that is not often widely appreciated is that most of the potential habitats where life might exist on our planet are cold. By volume, the "Cold Biosphere" represents approximately 90% of the living biosphere on Earth, with temperatures less that 4 degrees C ("home refrigerator" temperatures). Most of this cold biosphere is in the deep sea (79% by volume of the biosphere: Broad, 1998) and in polar regions. Further biological research in polar regions will substantially increase our understanding of the "Cold Biosphere" and its role in the sustainability of life on Earth. New research themes under consideration for IPY, such as NSF’s "Life in the Cold and Dark," will be key to understanding critical questions regarding life in polar regions and in the cold biosphere in general.

A major success of past IPYs, and in particular IGY, was the important legacy that continued into the future from training the next generation of scientific leaders in the US. This legacy of excellent science and training from IGY, started about 50 years ago, is still active today. For the next IPY, we must strongly encourage the active involvement and advanced training of the next generation of polar scientists. This, of course, must include outreach and educational activities to students of all ages, and to the general public, to encourage interest and careers in science and engineering. Additionally, during IPY we need to develop innovative educational and training programs designed to bring young scientists at the Ph.D. level to polar regions. We need to actively engage these young scientists in polar research by having them actually work "on the ice" during IPY. To this end, an international training program in Antarctic science (NSF-funded: "Integrative Biology and Adaptation of Antarctic Organisms") is planned for January 2008 at the US Antarctic Program's McMurdo Station in Antarctica. This program (that I have directed in the past and will continue to direct in IPY 2008) will involve bringing highly-qualified young investigators, selected from universities all over the US and some from international institutions, to Antarctica for the first time in their scientific careers. This next generation of potential leaders in polar science will be provided with intense training programs during which they will be exposed to the unique research opportunities in Antarctica. Training these individuals to conduct science in Antarctica "on the ice" will be a very different experience from learning about polar science from traditional classroom settings in the US.

I believe the societal benefits from undertaking further polar research will be immense. First, Antarctica holds a fascination for the general public. Second, there has been a dramatic recent increase in the public's awareness of the importance of polar regions in impacting events on a global scale (e.g., strong media coverage of ice sheet stability, with obvious implications for potential sea-level rise globally). Third, further research in polar regions will yield important insights into the connectivity of polar regions to the rest of Earth. In fact, the polar regions often drive fundamental processes in other parts of the world (e.g., major ocean currents and oceanic circulation patterns, with global implications for climate stability).

As a Principal Investigator and polar scientist myself, I will add a few comments here from my own experiences. In my more than 20 years of working in Antarctica, I have never before personally experienced such a widespread and intense interest by the general public in research in polar regions. In addition to increased interest in polar biology at scientific conferences and professional meetings, I receive numerous requests to speak about polar science at career days of elementary, middle, and high schools; to speak in a wide range of university settings, including discipline groups outside of the natural sciences; to address communities of retired citizens; and to present at natural history and community science museums. I attribute much of this recent surge in public interest about the state of our environment to be the result of highly publicized scientific discoveries in physics, chemistry and biology of polar regions.

I will conclude my comments here today by saying that, in my opinion, the timing is now most appropriate to launch a new IPY. The reasons for this go far beyond the timing of the 50th anniversary of IGY, although that is a valued reason too. The general public is certainly highly aware that the study of polar regions is critical to understanding our Earth. Scientific interest is high in wanting to have accurate information about polar regions and their role in climate stability and global processes.

Again, thank you for the opportunity to speak with you today. I would be pleased to address any questions that the members of the Subcommittee may have.

References:

Broad, W.J.,1998. *The Universe Below: Discovering the Secrets of the Deep Sea*, 432pp.

National Geographic, 1963. *Filling in Antarctica's Blank Spaces*, Volume 123: 297-298.

National Research Council, 2002. *Abrupt Climate Change: Inevitable Surprises*, National Academy Press, Washington D.C. 230 pp.

Biographical Sketch for Donal T. Manahan

Professor of Biological Sciences, University of Southern California
(Ph: 213-740-5793; E-mail: manahan@usc.edu; Web Site: http://usc.edu/manahanlab)

Education and Professional Preparation:

Undergraduate Institution:	Area of Focus:	Years:
BA, from Trinity College, Univ. of Dublin, Ireland	Zoology	1972-1976
Graduate Institution:		
PhD, from University of Wales, Bangor, UK	Marine Physiology	1976-1980
Advisor: Prof. D.J. Crisp, F.R.S.		
Postdoctoral Institution:		
University of California, Irvine	Cellular Physiology	1980-1983
Advisor: Dr. Grover C. Stephens		

Academic Appointments:

1983 to present: Assistant, to Associate, to Full Professor. Department of Biological Sciences, University of Southern California, Los Angeles, California 90089-0371

Sept 1992 to Sept 1993: Visiting Faculty, Division of Biology, California Institute of Technology, Pasadena, California (sabbatical year in the laboratory of Dr. Eric Davidson).

Some Senior Administrative and Service Positions Held:

- NSF, Internal Advisory Committee, Director of NSF's Office of Polar Programs (appointed February 2006).
- Chair, US National Academies' National Research Council's Polar Research Board (1999 to 2002) (member of Board, 1995-2002).
- NSF, Decadal Group-Planning Committee for Ocean Sciences 2000 (1998 to 2001).
- Dean of Research, USC College of Letters, Arts and Sciences (July 2000 to June 2005).
- Chair/Vice Chair, USC Department of Biological Sciences (Sept 1999 to July 2000).
- Director, USC Research Division of Marine Environmental Biology (1995 to 2000).
- Science Director, USC's Environmental Studies Program (1995 to 2000).

Recent Awards:

For Service (2000 to present):

2000 – a 6000-foot mountain in Antarctica named "*Manahan Peak*" for contributions to Antarctic research, education, and service to the science community.

2001 – appointed a lifetime "*National Associate*" of the United States' National Academies in recognition of [quote] "extraordinary service to the National Academies in their role as advisors to the Nation in matters of science, engineering, and health."

2005 – University of Southern California, College of Letters, Arts and Sciences Award for "Outstanding Leadership and Service."

Recent Awards for Research Papers (2000 to present):

Pace, D. and Manahan, D.T., 2000. Genetic variance and feeding rates in bivalve larvae. National Shellfisheries Association Annual Meeting, Seattle, Washington. Best Paper Award.

Green, A.J. and D.T. Manahan, 2004. Metabolic efficiency in fast-growing bivalve larvae. Society of Integrative and Comparative Biology. Best Paper Award in Comparative Physiology and Biochemistry.

Green, A.J. and D.T. Manahan, D.T., 2004. High growth efficiencies in Antarctic larvae. Ocean Science Research Conference, American Society of Limnology and Oceanography. Outstanding Poster Award.

Yu, P.C, A.L Moran and D.T. Manahan, 2004. Genetic variation in survival and growth recovery following prolonged starvation of invertebrate larvae. Ocean Science Research Conference, American Society of Limnology and Oceanography. Outstanding Poster Award.

Meyer, E., D. Hedgecock, and D.T. Manahan, 2006. Genomic analysis of growth in larvae of the *Crassostrea gigas*. Annual Meeting of National Shellfisheries Association, Monterey, California. Best Paper Award.

Recent Grants and Funded Research Projects (active during 2000 to present):

(1) NSF. Larval Dispersal at Hydrothermal Vents.
Co-investigators: L. Mullineaux (Woods Hole, MA), C. Young (Harbor Branch Oce. Inst.).
Duration: April 1997 to Mar 2002.

(2) US Dept. of Agriculture. Improving Pacific Oyster Broodstocks for Aquaculture.
Co-investigators: D. Hedgecock (USC), C. Langdon (Oregon State Univ.).
Duration: April 1997 to March 2002.

(3) NSF. Integrative Biology and Adaptation of Antarctic Marine Organisms.
Duration: March 1998 to February 2006.

(4) W.M. Keck Foundation. Experimental Research in Evolutionary Biology.
Co-investigators: M. Waterman, N. Arnheim, M. Nordborg (all at USC).
Duration: January 2002 to February 2006.

(5) NSF. Energetics of Protein Metabolism during Development of Antarctic Echinoderms.
Duration: April 2002 to March 2007.

(6) NSF. Genomic Approaches to Understanding Variation in Marine Larval Recruitment.
Co-investigators: D. Hedgecock (USC), E. Hofmann (Old Dominion), E. Powell (Rutgers).
Duration: July 2004 to June 2008.

(7) US Dept. of Agriculture. Crossbreeding Pacific oysters for high yield.
Co-investigators: D. Hedgecock (USC), C. Langdon (Oregon State Univ.).
Duration: July 2004 to June 2008.

(8) NSF. Integrative Biology and Adaptation of Antarctic Marine Organisms.
Graduate training grant with co-investigators.
Duration: August 2005 to September 2010.

Five Selected Publications (past 5 years – 2001 to 2006):

Pace, D.A., A. G. Marsh, P. K. Leong, A.J. Green, D. Hedgecock, and D. T. Manahan, 2006. Physiological bases of genetically determined variation in growth of marine invertebrate larvae: A study of growth heterosis in the bivalve *Crassostrea gigas*. Journal of Experimental Marine Biology and Ecology, 335: 188-209.

Pace, D.A. and D.T. Manahan, 2006. Fixed metabolic costs for highly variable rates of protein synthesis in sea urchin embryos and larvae. Journal of Experimental Biology, 209: 158-170.

Moran, A.L. and D.T. Manahan, 2004. Physiological recovery from prolonged starvation in larvae of Pacific oyster *Crassostrea gigas*. Journal of Experimental Marine Biology and Ecology, 306: 17-36.
Marsh, A.G., L.S. Mullineaux, C.M. Young and D.T. Manahan, 2001. Larval dispersal potential of the tubeworm *Riftia pachyptila* at deep-sea hydrothermal vents. Nature, 411: 77-80.
Marsh, A.G., R. Maxson and D.T. Manahan, 2001. High macromolecular synthesis with low metabolic cost in Antarctic sea urchin embryos. Science, 291: 1950-1952.

Five other selected publications (2000 and before):

Marsh, A.G., P.K.K. Leong, and D.T. Manahan, 2000. Gene expression and enzyme activities of the sodium pump during sea urchin development: Implications for indices of physiological state. Biological Bulletin, 199: 100-107.
Vavra, J.S. and D.T. Manahan, 1999. Protein metabolism in lecithotrophic larvae (Gastropoda: *Haliotis rufescens*). Biological Bulletin, 196: 177-186
Hoegh-Guldberg, O. and D.T. Manahan, 1995. Coulometric measurement of oxygen consumption during development of marine invertebrate embryos and larvae. Journal of Experimental Biology, 198: 19-30.
Manahan, D.T., 1990. Adaptations by invertebrate larvae for nutrient acquisition from seawater. American Zoologist, 30: 147-160.
Manahan, D.T., J.P. Davis, and G.C. Stephens, 1983. Bacteria-free sea urchin larvae: Selective uptake of neutral amino acids from seawater. Science, 220: 204-206 Teaching and Service Activities:

Research Statement: My work bridges the fields of animal physiology, developmental biology, and molecular biology – all studied in an environmental context. Most animals have complex life history strategies and early developmental stages (embryos, larvae) that are, in general, less well understood in comparison to adult phases of life cycles. I study developmental biology from the perspective of environmental biochemistry and physiology, in particular how developmental stages "work" in contrasting and 'extreme' environments. Some of the implications of such research for basic science, include – understanding the molecular biology and physiology of growth and development of cells and animals, and defining the biological mechanisms that set differences in metabolism. There are also 'applied' aspects to this research – e.g., the search for ways to improve the production of food from the ocean for human consumption, through the application of "hybrid vigor" to enhance growth rates of marine animals (cf. "Green Revolution" in agriculture) and the search for novel biochemical processes in 'extreme' environments (Antarctica).

Teaching Statement: I have taught at the university level for over 25 years. The undergraduate courses for which I specifically developed new curricular materials include: Animal Biochemistry and Physiology; Biological Diversity and Adaptation; Cellular Physiology; Humans and their Environment; and Introductory Biology (latter are large courses with several hundred students). Graduate (Ph.D.-level) courses include: Developmental Biology; Integrative Biology and Evolutionary Adaptation; Physiology and Metabolic Plasticity; Oceanography and Biology; and History of Science. For over a decade, I have also directed international biology training programs for PhD-level students and postdoctoral-level scientists in Antarctica. These NSF-funded educational programs have focused on themes of major and current interest in environmental science (e.g., global warming and the "ozone hole") and biological adaptations to environmental change, studied from different biological levels of analyses (from whole-organism to single genes). The individuals who have participated in these training programs were from ~120 different research institutions, representing over 20 different countries.